PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Aggidis *et al.*	:	Attorney Docket No. 04-40092-US
Serial No.: 10/784,544	:	Examiner: TBD
Filed: February 23, 2004	:	Group Art Unit: 3746
For: Improvements In Or Relating To Turbines And In Particular Pelton Wheel Turbines	:	

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

12/27/2004 GWORDOF1 00000021 180586 10784544
01 FC:1463 70.00 DA 130.00 OP

PETITION FOR ACCEPTANCE OF UNSIGNED DECLARATION PURSUANT TO 37 C.F.R. 1.47(a)

Sir:

Applicant hereby petitions the Commissioner pursuant to 37 C.F.R. § 1.47(a) to accept the Declaration and Power of Attorney submitted herewith (a copy of which is attached hereto as Exhibit A) in accordance with 35 U.S.C. § 118 and in satisfaction of the requirements of the Notice to File Missing Parts which issued in the above identified application on May 18, 2004, (a copy of which is attached hereto as Exhibit B).

Petition under 37 C.F.R. §1.47(a)

37 C.F.R. 1.47(a) provides that "If a joint inventor refuses to join in an application for patent . . . the application may be made by the other inventor on behalf of himself or herself and the non-signing inventor. The oath or declaration in such an application must be accompanied by a petition including proof of the pertinent facts, the fee set forth in §1.17(h), and the last known address of the non-signing inventor. . ."

Underlying Facts

Gilbert Gilkes & Gordon Limited, Canal Head North, Kendal, Cumbria, LA9 7BZ, United Kingdom, is the Applicant for and owner of British Patent Application 0304556.4, a copy of which is attached hereto as Exhibit C. British Patent Application 0304556.4 was filed on February 28, 2003, and identified George Athanasios Aggidis and Robert Catley as the inventors of the invention claimed therein.

On February 23, 2004, the above-identified United States Patent application was filed on behalf of Gilbert Gilkes & Gordon Limited. The United States Application claims priority from

12/23/2004 GWORDOF1 00000012 10784544
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the underlying British application pursuant to 35 U.S.C. § 119(a). A standard declaration and power of attorney for signature by the named inventors was forwarded for signature by Mr. Aggidis and Mr. Catley.

Mr. Catley signed the Declaration on September 16, 2004, identifying both Mr. Aggadis and Mr. Catley as the inventors of the invention claimed in the above-identified United States Patent Application. The Declaration and Power of Attorney signed by Mr. Catley.

Mr. Aggadis and Mr. Catley were employed by Gilbert Gilkes & Gordon Limited when the invention claimed in the preset application was made. Since that time, Mr. Haggadis has left the employ of Gilbert Gilkes & Gordon, Limited.

Efforts have been made by Gilbert Gilkes & Gordon Limited, as well as their attorney in the United Kingdom,to obtain Mr. Aggadis's signature on the Declaration for the above-identified United States Patent Application. As recently as Monday, 20 December 2004, Mr. Aggadis maintained his refusal to sign the Declaration for the above-identified United States Patent Application, although further efforts to obtain his signature continue.

The final extension for responding to the outstanding Notice to File Missing Parts, which issued on May 18, 2004, expires today, December 20, 2004 (with a five month extension,) and accordingly all patent rights in the United States will go abandoned absent satisfaction of the requirements of the Notice to File Missing Parts. Mr. Aggadis's refusal to sign the Declaration will thus irreperably harm both Gilbert Gilkes & Gordon Limited, as well as Robert Catley, by forcing the forfeiture of patent rights in the United States.

Argument

The Manual of Patent Examining Procedure provides that "All the available joint inventors must (1) make oath or declaration on their own behalf as required by 37 C.F.R. 1.63 or 1.175 and (2) make oath or declaration on behalf of the nonsigning joint inventor as required by 37 C.F.R. 1.64. ***An Oath or Declaration signed by all the available joint inventors with the signature block of the non-signing inventor(s) left blank may be treated as having been signed by all the available joint inventors on behalf of the nonsigning inventor***, unless otherwise indicated." MPEP §409.03(a) (citations ommitted).

The Declaration and Power of Attorney attached hereto as Exhibit A contains the oath of Mr. Catley on his own behalf as required by 37 C.F.R. § 1.63 (element 1, above), as well as clearly identifies Mr. Aggadis as the joint inventor. Accordingly, Applicant herewith petitions that the Declaration attached hereto as Exhibit A be treated as having been signed by all the available joint inventors on behalf of the nonsigning inventor, pursuant to MPEP § 409.03(a)(A)(2), and that the enclosed Declaration be accepted as pursuant to 35 U.S.C. § 118 and 37 C.F.R. § 1.47(a). Furthermore, the Declaration attached as Exhibit A contains identification of the present address of Mr. Aggadis, 152 Windmere Road, Kendal, Cumbria LA9 5EZ, United Kingdom, in satisfaction of the requirement of 37 C.F.R. 1.47(a), and the petition fee under 37 C.F.R. 1.17(h) is remitted herewith.

Accordingly, applicant requests that submission of the Declaration and Power of Attorney attached hereto as Exhibit A be accepted pursuant to 37 CFR 1.47(a) in satisfaction of the requirement for the named inventors to submit an oath of inventorship pursuant to 35 USC 135 and 37 CFR 1.63, and that the above-identified United States Patent Application be considered complete, and that the application be forwarded for examination.

The Commissioner is hereby authorized to charge any deficiencies or credit any overpayment to Deposit Account No. 18-0586.

CERTIFICATE OF MAILING UNDER 37 C.F.R. 1.10

EXPRESS MAIL Mailing Label Number: EV 481 404 318 US
Date of Deposit: December 20, 2004

I hereby certify that this paper and/or fee is being deposited with the United States Postal Service, **"EXPRESS MAIL – POST OFFICE TO ADDRESSEE"** service under 37 C.F.R. 1.10, on the date indicated above, and is addressed to the Commissioner for atents, P. O. Box 1450, Alexandria, VA 22313-1450

Franziska Reichstein
(Name of person mailing paper.)

Signature of person mailing paper.)

Respectfully submitted,

Carl H. Pierce
Registration No. 45,730
REED SMITH LLP
2500 One Liberty Place
1650 Market Street
Philadelphia, PA 19103-7301
(215) 241-7970
Attorney for Applicants

Docket No.: 04-40092-US

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are stated below next to my name.

I believe I am an original, first, and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled:

IMPROVEMENTS IN OR RELATING TO TURBINES AND IN PARTICULAR PELTON WHEEL TURBINES

the specification of which was filed with the United States Patent and Trademark Office on February 23, 2004 and accorded Serial No. 10/784,544.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with 37 CFR §1.56.

I hereby claim foreign priority benefits under 35 U.S.C. §119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT international application which designated at least one country other than the United States, listed below and have also identified below any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S)

COUNTRY/OFFICE	APPLICATION NO.	DATE OF FILING	PRIORITY CLAIMED
Great Britain	0304556.4	February 28, 2003	☒ YES NO ☐
			☐ YES NO ☐

I hereby claim the benefit under 35 U.S.C. §119(e) of any United States Provisional application(s) listed below.

PROVISIONAL APPLICATION NUMBER	DATE OF FILING
None	

Docket No.: 04-40092-US

I hereby claim the benefit under 35 U.S.C. §120 of any United States application(s) or §365(c) of any PCT international application(s) designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of 35 U.S.C.§112, I acknowledge the duty to disclose material information as defined in 37 CFR §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. §120

Application Serial No.	Date of Filing	Status (check one)		
		Patented	Pending	Abandoned
None		☐	☐	☐
		☐	☐	☐

And I hereby appoint Louis M. Heidelberger, Reg. No. 27,899; John W. Goldschmidt, Jr., Reg. No. 34,828; William J. McNichol, Jr., Reg. No. 31,179; Maryellen Feehery, Reg. No. 44,677; Carl H. Pierce, Reg. No. 45,730; Nanda P.B.A. Kumar, Reg. No. 44,853; Thomas J. McWilliams, Reg. No. 44,930; Matthew J. Esserman, Reg. No. 41,536; Jonathan M. Darcy, Reg. No. 44,054; Todd A. Norton, Reg. No. 48,636; Edward P. Behm, Jr., Reg. No. 52,606; Frederick H. Colen, Reg. No. 28,061; Gene A. Tabachnick, Reg. No. 33,801; Maria N. Bernier, Reg. No. 37,433; Barry J. Coyne, Reg. No. 43,566; Kirsten R. Rydstrom, Reg. No. 38,603; Paul D. Bangor, Jr., Reg. No. 34,768; Charles H. Dougherty, Jr., Reg. No. 42,494; Robert D. Kucler, Reg. No. 45,908; Cheryl L. Gastineau, Reg. No. 39,469, Ian K. Samways, Reg. No. 36,664; James Dilmore, Reg. No. 51,618; Marc J. Farrell, Reg. No. 37,826; Stanley P. Fisher, Reg. No. 24,344; Juan Carlos A. Marquez, Reg. No. 34,072; Gerald Kiel, Reg. No. 25,116; Eugene Le Donne, Reg. No. 35,930; Jules Goldberg, Reg. No. 24,408; Lloyd McAulay, Reg. No. 20,423; Arthur Dresner, Reg. No. 24,403; William H. Dippert, Reg. No. 26,723; Stephen Chin, Reg. No. 39,938; Michael I. Wolfson, Reg. No. 24,750; Harry K. Ahn, Reg. No. 40,243; Daniel P. Lent, Reg. No. 44,867; and Mary E. Buckles, Reg. No. 31,907 of Reed Smith LPP as my attorneys or agents with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

Address all correspondence to Louis M. Heidelberger, Esq., Reed Smith LLP, 2500 One Liberty Place, 1650 Market Street, Philadelphia, PA 19103. Address all telephone calls to Louis M. Heidelberger. (215) 851-8100; telefax (215) 851-1420.

Docket No.: 04-40092-US

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

FULL NAME OF SOLE OR FIRST INVENTOR		
George *(Given Name)*	Athanasios *(Middle Initial or Name)*	Aggidis *(Family or Last Name)*
Inventor's signature:		
Date:		
Country of Citizenship:	Greece	
Residence:	Kendal	United Kingdom
	(City)	*(State or Foreign Country)*
Post Office Address:	152 Windermere Road, Kendal, Cumbria LA9 5EZ, United Kingdom	

FULL NAME OF SECOND INVENTOR		
Robert *(Given Name)*	*(Middle Initial or Name)*	Catley *(Family or Last Name)*
Inventor's signature:	R Catley	
Date:	16/9/2004	
Country of Citizenship:	Great Britain	
Residence:	Kendal	United Kingdom
	(City)	*(State or Foreign Country)*
Post Office Address:	44 Sparrowmire Lane, Kendal, Cumbria LA9 5PX, United Kingdom	

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
10/784,544	02/23/2004	George Athanasios Aggidis	04-40092-US-US

CONFIRMATION NO. 7766

FORMALITIES LETTER

OC0000000012701292

07066
REED SMITH LLP
2500 ONE LIBERTY PLACE
1650 MARKET STREET
PHILADELPHIA, PA 19103

Date Mailed: 05/18/2004

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items and pay any fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The statutory basic filing fee is missing.
  Applicant must submit $ **770** *to complete the basic filing fee for a non-small entity. If appropriate, applicant may make a written assertion of entitlement to small entity status and pay the small entity filing fee (37 CFR 1.27).*
- The oath or declaration is unsigned.
- To avoid abandonment, a late filing fee or oath or declaration surcharge as set forth in 37 CFR 1.16(e) of $130 for a non-small entity, must be submitted with the missing items identified in this letter.

The applicant needs to satisfy supplemental fees problems indicated below.

The required item(s) identified below must be timely submitted to avoid abandonment:

- Additional claim fees of **$36** as a non-small entity, including any required multiple dependent claim fee, are required. Applicant must submit the additional claim fees or cancel the additional claims for which fees are due.

SUMMARY OF FEES DUE:

Total additional fee(s) required for this application is ~~$936~~ 1,020.00 for a Large Entity 790.00

- ~~$770~~ Statutory basic filing fee.
- **$130** Late oath or declaration Surcharge.

- Total additional claim fee(s) for this application is ~~$36~~ 100.00

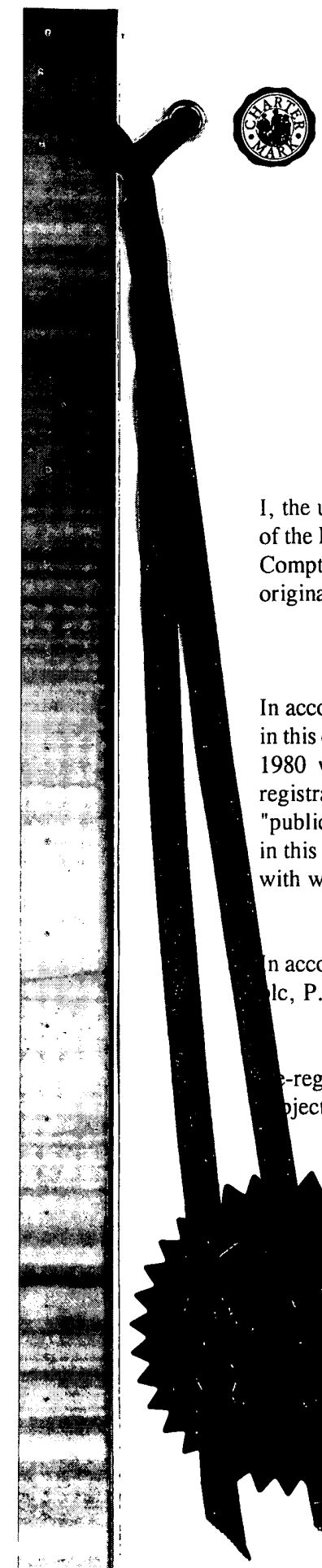
- $36 for 2 total claims over 20.

100.00

Replies should be mailed to: Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

A copy of this notice MUST be returned with the reply.

Customer Service Center
Initial Patent Examination Division (703) 308-1202
PART 2 - COPY TO BE RETURNED WITH RESPONSE



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The Patent Office

INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

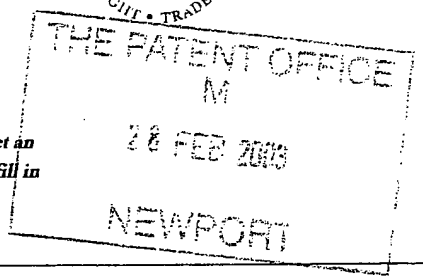
Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed K Behen

Dated 3 March 2004

Patents Form 1/77

Patent 1977
Rule 16



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P01/7700 0.00-0304556.4

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

1. Your reference

SMC/BC/P5159

2. Patent application number
(The Patent Office will fill in this part)

0304556.4

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Gilbert Gilkes & Gordon Ltd
Canal Head North
Kendal
Cumbria, LA9 7BZ

Patents ADP number *(if you know it)*

8575607001

If the applicant is a corporate body, give the country/state of its incorporation

UK (Unitary Authority)

4. Title of the invention

Improvements in or relating to turbines and in particular Pelton wheel turbines

5. Name of your agent *(if you have one)*

ROYSTONS

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Tower Building
Water Street
Liverpool
L3 1BA

Patents ADP number *(if you know it)*

1438001 ✓

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

Yes

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	9
Claim(s)	4
Abstract	1
Drawing(s)	2+2

10. If you are also filing any of the following, state how many against each item.

Priority documents	-
Translations of priority documents	-
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	-
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	-
Any other documents *(please specify)*	-

11. I/We request the grant of a patent on the basis of this application.

Signature ROYSTONS – Authorised Representative Date 27/02/2003

12. Name and daytime telephone number of person to contact in the United Kingdom: S.M. Cardwell 0151-236 5147/1417

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.

b) Write your answers in capital letters using black ink or you may type them.

c) If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.

d) If you have answered 'Yes' Patents Form 7/77 will need to be filed.

e) Once you have filled in the form you must remember to sign and date it.

f) For details of the fee and ways to pay please contact the Patent Office.

TITLE : Improvements in or relating to turbines and in particular Pelton wheel turbines.

DESCRIPTION

The present invention relates to an improved construction of turbine rotor and has particular application to a Pelton wheel runner, but without limitation to same.

A Pelton wheel runner comprising a plurality of buckets on a common hub is traditionally made as a single casting. This single casting is usually difficult to cast due to the complexity and proximity of the individual buckets. Following casting, the machining of the Pelton wheel is not the easiest of operations, and the surfaces of the buckets have to be smoothed with a grinding tool. The problem of access for the tool towards the root of the buckets makes the job of finishing a long, expensive and tedious process requiring a high degree of skill.

A Pelton wheel is most usually used to convert the energy of moving water into rotational energy to drive a load. Considerable wear of the buckets can occur and it is common for the wheels to be removed for repair, eg: by a weld repair. If the damaged bucket is beyond weld repair then the whole Pelton runner is scrap.

Proposals have been made in DE 3938357 to construct a Pelton wheel from a plurality of individual segmental elements each formed with a plurality of buckets, and which are assembled together as a unit by securing them between opposed flanged collars by pin means passing through axial holes in the individual segmental elements and by the use of headed bolts whose heads engage with oppositely disposed end caps and whose shanks engage threadingly with the pins to cause the individual segmental elements to be clamped axially between the flanged collars. In addition,

pairs of pin means are provided at the junction of adjacent individual segmental elements to facilitate fine adjustment of the individual segmental elements, and hence the buckets, by way of ball/conical faces. The construction has the disadvantage that it requires many parts, many of which require precision machining, and assembly requires precision fitting.

It is an aim of the present invention to provide an improved construction which provides a solution to these problems and to provide a unique combination of technical (engineering) benefits as well as manufacturing cost savings in relation to a Pelton wheel runner construction.

It is a further aim to provide a beneficial construction of turbine rotor for applications other than that of a Pelton wheel runner.

Accordingly, a first aspect of the present invention provides a turbine rotor having an axis of rotation and comprising a hub or axle element, and a plurality of individual radial body members carrying one or more impeller elements, and wherein the plurality of radial body members are secured with respect to said hub or axle element, each radial body member having leading and trailing radial abutment surfaces relative to the direction of rotation of the rotor that contact with the respective radial abutment surfaces of adjacent radial body members, and each radial body member further comprising at least one further abutment means, and the turbine rotor further comprising locating means in direct or indirect engagement with the further abutment means of the radial body members, and wedging means which is tapered in the radial direction relative to the axis of rotation and which acts between said radial body members and said locating means, and further comprising means

acting via said wedging means to draw the radial body members radially inwards and hold them together as a unit.

The radial body member may be common to a plurality of radially disposed impeller elements, eg: two, three, etc. Preferably the plurality of impeller elements are formed integrally with the associated radial body member, eg: by casting, but they could be secured to the body member by any other positive fixing means. However, in a preferred embodiment each impeller element is formed with its own radial body member. A lost wax investment casting process is preferred. The body members form segments of the rotor and the opposite radial abutment surfaces thereof are tapered so that they converge on and intersect at the axis of rotation.

Preferably the further abutment means comprises axial abutment means. Preferably each radial body member comprises two further abutment means which are disposed to opposite axial ends thereof. Preferably the locating means comprises two locating elements that are engageable with a respective one of the two further abutment means of the radial body members.

The wedging means may be a separate member or members interposed between the further abutment means and the locating means. More preferably the wedging means is incorporated in at least one of the further abutment means or said locating means. Preferably the or each locating means comprises an annular locating ring which is provided with a frusto conical abutment that is co-operable with a respective one of the further abutment means of the radial body members. Preferably the or each further abutment means of each radial body means is radially tapered. Conveniently the tapered abutment means is in the form of a flange extending in the axial direction, and, on assembly, the flanges of all the radial body elements and

hence the impeller elements form an annular (frusto conical) tapered flange that is acted on by the frusto conical abutment of the annular locating ring.

Preferably means is provided for directly securing together the respective pair of locating elements. Said means comprises an axial clamping means and may be used on its own to locate the radial body elements and hence the impeller elements together as a unit by drawing together the two annular locating elements. Means is provided to connect the locating rings with respect to a connecting shaft, eg: the axle element. A shaft key may be used to connect the locating elements to the shaft. Each locating element may have its own key, or one key may be common to both, or only one key used and the clamping means used to connect the keyed element to the non-keyed element. More preferably each of the annular locating rings is connectable individually with a connecting shaft, eg: the axle element. Conveniently the means connecting the or each locating element to the connecting shaft comprises a tapered locking element, such as elements made by the German company Ringfeder or others. In a preferred construction each locating ring is provided with its own tapered locking ring (comprising two relatively moveable parts) which engages between the shaft and the locating ring. The action of tightening the locking element generates an axial movement of the locating ring relative to the shaft and thereby causes the radial body members and hence the impeller elements to be drawn inwardly by virtue of the co-operating tapered abutment surfaces. The provision of radial leading and trailing abutments on the radial body members gives rise to a circumferential wedging action as the radial body members are drawn inwardly by the annular locating rings.

The respective means to locate each annular locating element may be provided in addition to or as an alternative to the aforesaid axial clamping means. Other means of securing the annular locating rings to the axle may be used.

According to a preferred embodiment, the invention provides a turbine rotor having an axis of rotation and comprising a hub or axle element, a plurality of individual radial body members carrying one or more impeller elements, and two annular collars each having a frusto conical abutment surface, and wherein each radial body member comprises a frusto conical tapered flange to opposite ends thereof, the frusto conical tapered flanges to one axial end being co-operable with the frusto conical abutment surface of one annular collar, and the frusto conical tapered flanges to the other axial end being co-operable with the frusto conical abutment surface of the other annular collar, and further comprising means to secure the radial body members with regard to said hub or axle, and means acting via said frusto conical surfaces to draw the radial body members radially inwards.

In a preferred application the turbine rotor is a Pelton wheel runner and the impeller elements are buckets. The invention is described by way of example only hereinafter in relation to its application to a Pelton wheel runner. The use of conical tapered shoulders clamps the buckets by forcing them together, in a simple manner and has the advantage that it uses a minimum number of components and no precision fitting is required.

The present invention will now be described further, by way of example only, with reference to the accompanying drawings; in which:-

Figure 1 is a broken away front view of a Pelton wheel runner embodying the invention,

Figure 2 is a top view of the Pelton wheel runner of Figure 1,

Figure 3 is a partial section of Figure 1, and

Figure 4 is a perspective view of a bucket used in the embodiment of Figures 1 to 3.

Referring to the drawings, a turbine rotor of the type comprising a Pelton wheel runner is described and illustrated. However, whilst the present invention is described by way of example in relation to its application to Pelton wheel runner, it will be apparent to one skilled in the art that it can be applied to other types of turbine rotor, and the protection is not limited to a Pelton wheel runner.

The Pelton wheel runner according to the illustrated embodiment is made of a plurality of individual segments and each segment is formed with one bucket 1 in the described example and are conveniently referred to as bucket segments. The bucket segments are assembled together in a radial disposition relative to an axis of rotation X-X. Eighteen segments each with one bucket are shown in the illustrated example but it will be understood that the number of segments and the number of buckets per segment may vary according to any particular design requirement. In the illustrated embodiment the wheel is adapted to be mounted on a shaft 6.

Each bucket segment has a body 11 which has, in relation to the direction of rotation of the wheel, leading 13 and trailing 15 radial abutment surfaces. In assembling the plurality of bucket segments together to form a runner, the trailing abutment surface of the body of one bucket segment engages with the leading abutment surface of the body of the next adjacent bucket segment. For simplicity the radial abutment surfaces are plain surfaces, but could include ribs and rebates as

desired to limit machining and/or for location purposes. Any ribs or rebates should not inhibit radial movement for locating purposes as described further hereinafter.

The axial end faces of the runner are defined by opposite axial faces 17,19 of the individual bucket segments. The opposite axial faces each include an axially projecting radially tapered abutment 21 which, when the plurality of bucket segments are assembled together define an axially extending radially tapered annular flange 23 or frusto conical shoulder to each axial end of the runner. Each bucket segment body has a radially inwardly directed surface 25.

In the illustrated embodiment the hub of the Pelton wheel runner is defined by two annular elements 26,27 which form part of the impeller element locating means. Each annular element or locating ring has an annular recess 29 to capture the annular flange of the bucket segments. More particularly one annular element 26 has abutment means 31 disposed to engage with the radially tapered abutment 21 of each of the plurality of bucket segments disposed to one axial end thereof, whilst the other annular element 27 has abutment means 33 disposed to engage with the radially tapered abutment 21 of the opposite end of the bucket segment. More particularly each annular element 26,27 has a tapered frusto conical abutment. Preferably the angle of inclination of the respective tapered abutments of the bucket segments and the flange correspond.

First means for securing the two halves of the hub together is provided by a plurality of threaded bolts 35 whose heads 37 are engaged in respective recesses 38 in one of the halves and whose threaded shanks 39 engage with respective threaded holes 41 in the other half. As will be seen from Figure 3 the two annular elements are drawn together in an axial direction by the action of the bolt, thereby drawing the

tapered abutments thereof in to contact with the tapered flanges of the bucket segments. This in turn applies a radially directed clamping force to the bucket segments drawing them radially inwardly. The inward movement is resisted by the co-operating engagement between the radial abutment surfaces of the bucket segments. More preferably, and as detailed in the illustrated embodiment, each of the annular elements has its own tapered clamping element 34,38 by which each is secured individually to the shaft 6. The construction of the tapered locking elements is such that on tightening there is a relative axial movement between the shaft and the annular element. More particularly the tapered clamping element engages positively with the shaft whilst the annular element moves axially with respect thereto. This determines the final clamping force applied to the bucket segments and, where provided in addition to the first clamping means, overrides the action of the first clamping means.

In the illustrated embodiment the clamping bolts 35 are shown on substantially the same diameter as the locking element 38 and inset behind it. In an alternative design the clamping bolts are disposed at a greater radial distance from the axis X-X, closer towards the neck of the buckets, (especially for larger diameter units) and are accessible from one axial end when the element 38 or any alternative fixing element is in position.

By providing tapered flanges to either axial end of the runner relative to its central plane Y-Y and corresponding tapered flanges on both annular elements, the clamping operation will serve to draw the bucket segments uniformly radially inwardly which is desirable for most applications. However in some applications this may be seen as unnecessary and one of the axial ends of the runner may be provided

with a simple abutment surface on each bucket segment that is configured to allow radially inward movement under the action of co-operating tapered abutments of the other axial end of the runner.

CLAIMS

1. A turbine rotor having an axis of rotation and comprising a hub or axle element, and a plurality of individual radial body members carrying one or more impeller elements, and wherein the plurality of radial body members are secured with respect to said hub or axle element, each radial body member having leading and trailing radial abutment surfaces relative to the direction of rotation of the rotor that contact with the respective radial abutment surfaces of adjacent radial body members, and each radial body member further comprising at least one further abutment means, and the turbine rotor further comprising locating means in direct or indirect engagement with the further abutment means of the radial body members, and wedging means which is tapered in the radial direction relative to the axis of rotation and which acts between said abutment means and said locating means, and further comprising means acting via said wedging means to draw the radial body members radially inwards and hold them together as a unit.

2. A turbine rotor as claimed in claim 1 to which the radial body member is common to a plurality of radially disposed impeller elements.

3. A turbine rotor as claimed in claim 2 in which the plurality of impeller elements are formed integrally with the associated radial body member

4. A turbine rotor as claimed in claim 2 in which the plurality of impeller elements are discrete members that are secured to the body member by positive fixing means.

5. A turbine rotor as claimed in claim 1 in which each impeller element is formed with its own radial body member.

6. A turbine rotor as claimed in any one of claims 1 to 5 in which the body members form segments of the rotor and the leading and trailing radial abutment surfaces thereof are tapered so that they converge on and intersect at the axis of rotation.

7. A turbine rotor as claimed in any one of claims 1 to 6 in which the further abutment means comprises axial abutments means.

8. A turbine rotor as claimed in any one of claims 1 to 7 in which each radial body member comprises two of said further abutment means which are disposed to opposite axial ends thereof.

9. A turbine rotor as claimed in claim 8 in which the locating means comprises two locating elements that are engageable with a respective one of the two further abutment means of the radial body members.

10. A turbine rotor as claimed in any one of claims 1 to 9 in which the wedging means may comprise one or more separate members interposed between the further abutment means and the locating means.

11. A turbine rotor as claimed in any one of claims 1 to 9 in which the wedging means is incorporated in at least one of the further abutment means of each of the radial body members or said locating means.

12. A turbine rotor as claimed in any one of claims 1 to 11 in which the or each locating means comprises an annular locating ring which is provided with a frusto conical abutment.

13. A turbine rotor as claimed in any one of claims 1 to 9 or claim 12 when appended in any one of claim 1 to 9 in which the or each further abutment means of each radial body means is radially tapered.

14. A turbine rotor as claimed in claim 13 when dependent on claim 12 in which the radially tapered abutment means is in the form of a flange extending in the axial direction, and, wherein on assembly, the flanges of all the radial body elements form an annular frusto conical tapered flange that is acted on by the frusto conical abutment of the annular locating ring.

15. A turbine rotor as claimed in claim 9 in which means is provided for directly securing together the two locating elements.

16. A turbine rotor as claimed in claim 15 in which the securing means comprises an axial clamping means.

17. A turbine rotor as claimed in any one of the preceding claims in which means is provided to secure the locating means individually to a separate connecting member.

18. A turbine rotor as claimed in claim 17 in which the separate connecting member comprises the axle element.

19. A turbine rotor as claimed in claims 17 or 18 when dependent on claim 12 or any of claims 13 to 16 when dependent on claim 12 in which a respective means is provided to connect the respective locating rings to the connecting member.

20. A turbine rotor as claimed in claim 19 in which said means comprises a tapered locking element.

21. A turbine rotor as claimed in claim 20 in which each locating ring is provided with its own tapered locking ring comprising two relatively moveable parts which

engage between the connecting member and the locating ring and in which at least one locking ring acts to generate an axial movement of the locating ring relative to the connecting member and thereby cause the radial body members and hence the impeller elements to be drawn inwardly by virtue of the co-operating tapered abutment surfaces.

22. A turbine rotor as claimed in any one of claims 17 to 21 when dependent on claim 16 in which the respective means to locate each annular locating element are provided in addition to the aforesaid axial clamping means.

23. A turbine rotor as claimed in any one of the preceding claims in which the turbine rotor is a Pelton wheel runner and the impeller elements are buckets.

24. A turbine rotor constructed and arranged substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

ABSTRACT

A turbine rotor (eg: a Pelton wheel) is described which comprises a plurality of individual radial body members (11) comprising one or more impeller elements (eg: buckets) (1). The radial body members comprises segments which have leading (13) and trailing (15) radial abutment surfaces that contact with the respective radial abutment surfaces of adjacent radial body members when assembled as a unit. Each radial body member comprises at least one further abutment (21), preferably two at opposite axial ends (17,19) thereof, and locating means (26,27) is provided which co-operates with the further abutment means, preferably directly. Wedging means which is tapered in the radial direction relative to the axis of rotation of the turbine rotor, acts between the radial body members and the locating means, and means is provided which acts via said wedging means to draw the radial body members radially inwards to hold them together as a unit.

More particularly the locating means comprises two collars (26,27) which are engageable with a respective one of the axial end abutments (21) of the radial body members, and the wedging means comprises frusto conical formations of the further abutments of the radial body members and the locating means.

The means acting via the wedging means to draw the body members radially inwards comprises axial clamping means (35) operable between the two collars and/or taper action locating means (34,38) securing the two collars to a connecting shaft or axle element (6).

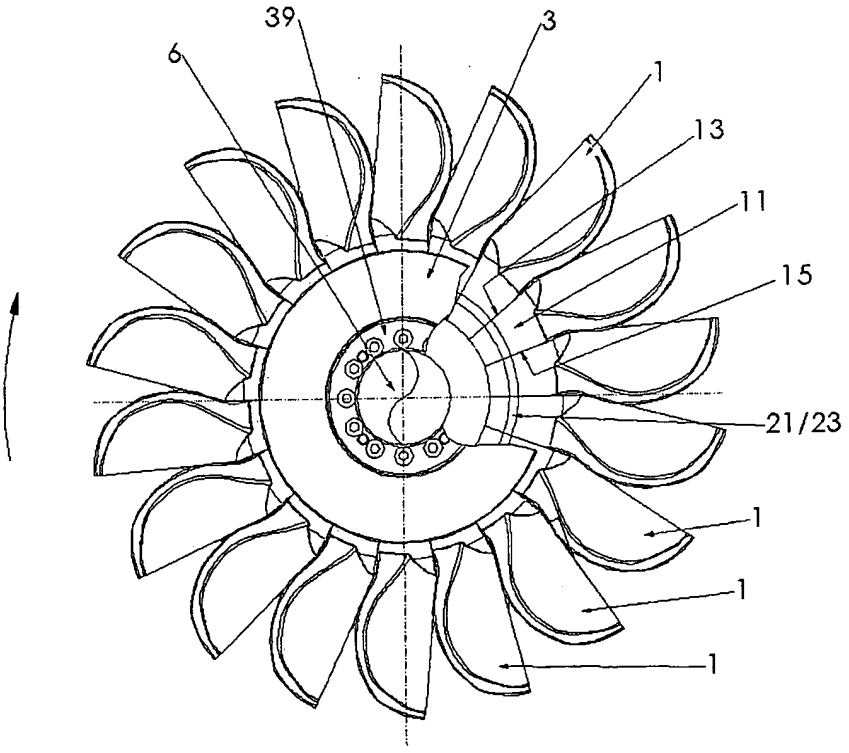


FIGURE 1

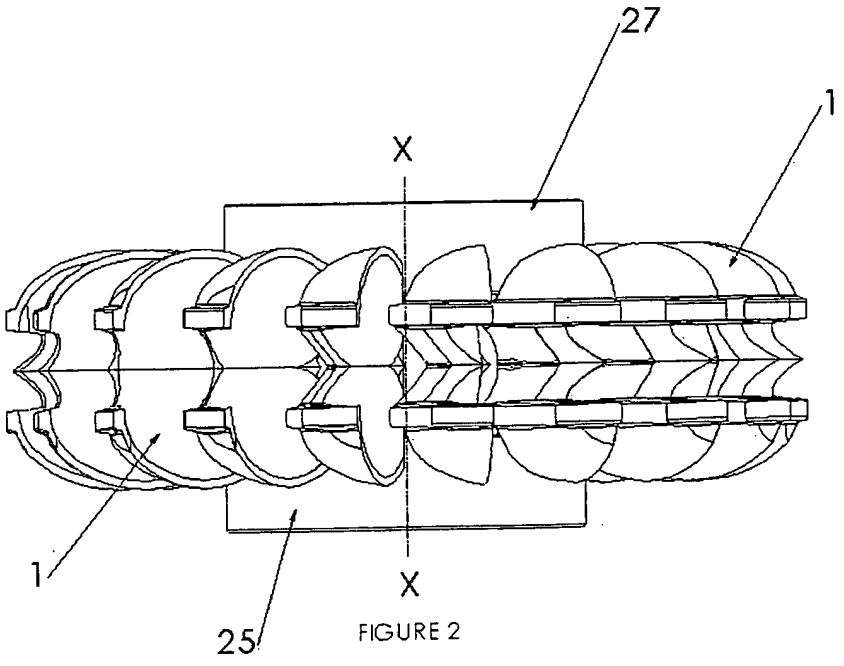


FIGURE 2

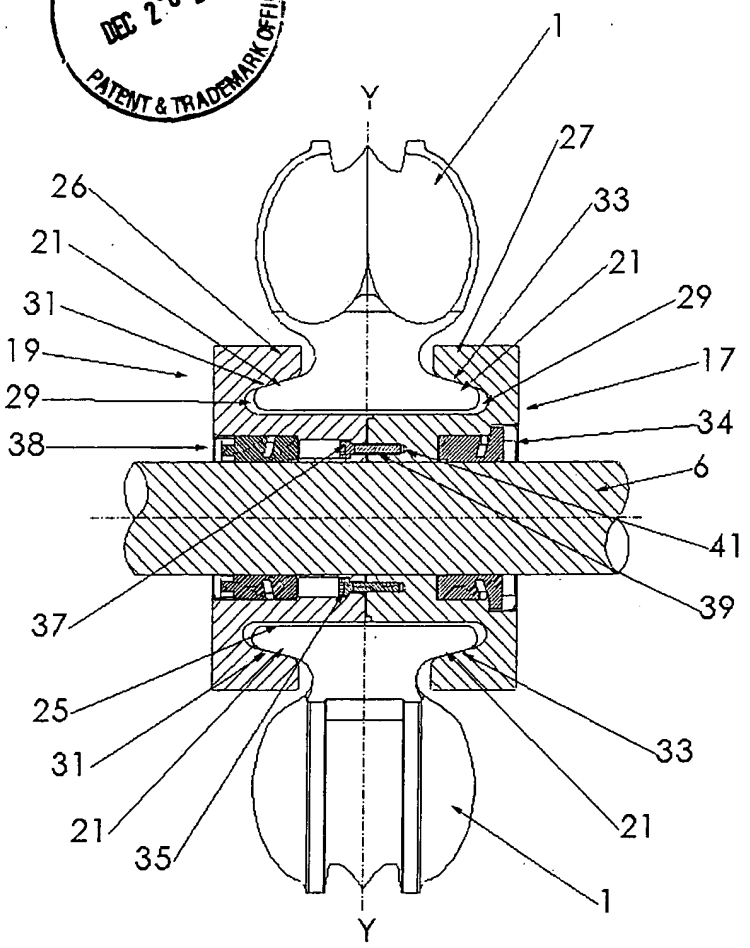


FIGURE 3

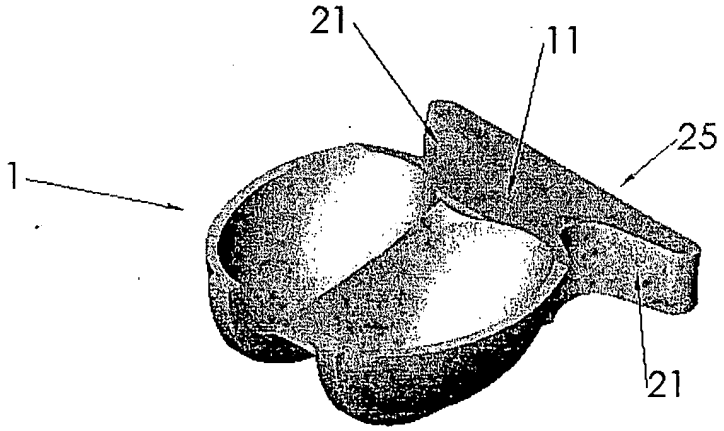
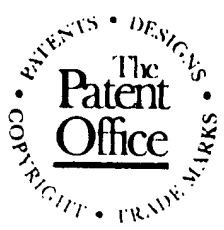


FIGURE 4



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Signed K Behen

Dated 3 March 2004

Patents Form 1/77

Patent 1977
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The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

1. Your reference

SMC/BC/P5159

2. Patent application number
(The Patent Office will fill in this part)

0304556.4

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Gilbert Gilkes & Gordon Ltd
Canal Head North
Kendal
Cumbria, LA9 7BZ

Patents ADP number *(if you know it)*

8575607001

If the applicant is a corporate body, give the country/state of its incorporation

UK

4. Title of the invention

Improvements in or relating to turbines and in particular Pelton wheel turbines

5. Name of your agent *(if you have one)*

ROYSTONS

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Tower Building
Water Street
Liverpool
L3 1BA

Patents ADP number *(if you know it)*

1438001 ✓

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

Yes

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	9
Claim(s)	4
Abstract	1
Drawing(s)	2 + 2

10. If you are also filing any of the following, state how many against each item.

Priority documents	-
Translations of priority documents	-
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	-
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	-
Any other documents *(please specify)*	-

11. I/We request the grant of a patent on the basis of this application.

Signature Date

ROYSTONS – Authorised Representative 27/02/2003

12. Name and daytime telephone number of person to contact in the United Kingdom

S.M. Cardwell 0151-236 5147/1417

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Notes

a) If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.

b) Write your answers in capital letters using black ink or you may type them.

c) If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.

d) If you have answered 'Yes' Patents Form 7/77 will need to be filed.

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TITLE : Improvements in or relating to turbines and in particular Pelton wheel turbines.

DESCRIPTION

The present invention relates to an improved construction of turbine rotor and has particular application to a Pelton wheel runner, but without limitation to same.

A Pelton wheel runner comprising a plurality of buckets on a common hub is traditionally made as a single casting. This single casting is usually difficult to cast due to the complexity and proximity of the individual buckets. Following casting, the machining of the Pelton wheel is not the easiest of operations, and the surfaces of the buckets have to be smoothed with a grinding tool. The problem of access for the tool towards the root of the buckets makes the job of finishing a long, expensive and tedious process requiring a high degree of skill.

A Pelton wheel is most usually used to convert the energy of moving water into rotational energy to drive a load. Considerable wear of the buckets can occur and it is common for the wheels to be removed for repair, eg: by a weld repair. If the damaged bucket is beyond weld repair then the whole Pelton runner is scrap.

Proposals have been made in DE 3938357 to construct a Pelton wheel from a plurality of individual segmental elements each formed with a plurality of buckets, and which are assembled together as a unit by securing them between opposed flanged collars by pin means passing through axial holes in the individual segmental elements and by the use of headed bolts whose heads engage with oppositely disposed end caps and whose shanks engage threadingly with the pins to cause the individual segmental elements to be clamped axially between the flanged collars. In addition,

pairs of pin means are provided at the junction of adjacent individual segmental elements to facilitate fine adjustment of the individual segmental elements, and hence the buckets, by way of ball/conical faces. The construction has the disadvantage that it requires many parts, many of which require precision machining, and assembly requires precision fitting.

It is an aim of the present invention to provide an improved construction which provides a solution to these problems and to provide a unique combination of technical (engineering) benefits as well as manufacturing cost savings in relation to a Pelton wheel runner construction.

It is a further aim to provide a beneficial construction of turbine rotor for applications other than that of a Pelton wheel runner.

Accordingly, a first aspect of the present invention provides a turbine rotor having an axis of rotation and comprising a hub or axle element, and a plurality of individual radial body members carrying one or more impeller elements, and wherein the plurality of radial body members are secured with respect to said hub or axle element, each radial body member having leading and trailing radial abutment surfaces relative to the direction of rotation of the rotor that contact with the respective radial abutment surfaces of adjacent radial body members, and each radial body member further comprising at least one further abutment means, and the turbine rotor further comprising locating means in direct or indirect engagement with the further abutment means of the radial body members, and wedging means which is tapered in the radial direction relative to the axis of rotation and which acts between said radial body members and said locating means, and further comprising means

acting via said wedging means to draw the radial body members radially inwards and hold them together as a unit.

The radial body member may be common to a plurality of radially disposed impeller elements, eg: two, three, etc. Preferably the plurality of impeller elements are formed integrally with the associated radial body member, eg: by casting, but they could be secured to the body member by any other positive fixing means. However, in a preferred embodiment each impeller element is formed with its own radial body member. A lost wax investment casting process is preferred. The body members form segments of the rotor and the opposite radial abutment surfaces thereof are tapered so that they converge on and intersect at the axis of rotation.

Preferably the further abutment means comprises axial abutment means. Preferably each radial body member comprises two further abutment means which are disposed to opposite axial ends thereof. Preferably the locating means comprises two locating elements that are engageable with a respective one of the two further abutment means of the radial body members.

The wedging means may be a separate member or members interposed between the further abutment means and the locating means. More preferably the wedging means is incorporated in at least one of the further abutment means or said locating means. Preferably the or each locating means comprises an annular locating ring which is provided with a frusto conical abutment that is co-operable with a respective one of the further abutment means of the radial body members. Preferably the or each further abutment means of each radial body means is radially tapered. Conveniently the tapered abutment means is in the form of a flange extending in the axial direction, and, on assembly, the flanges of all the radial body elements and

hence the impeller elements form an annular (frusto conical) tapered flange that is acted on by the frusto conical abutment of the annular locating ring.

Preferably means is provided for directly securing together the respective pair of locating elements. Said means comprises an axial clamping means and may be used on its own to locate the radial body elements and hence the impeller elements together as a unit by drawing together the two annular locating elements. Means is provided to connect the locating rings with respect to a connecting shaft, eg: the axle element. A shaft key may be used to connect the locating elements to the shaft. Each locating element may have its own key, or one key may be common to both, or only one key used and the clamping means used to connect the keyed element to the non-keyed element. More preferably each of the annular locating rings is connectable individually with a connecting shaft, eg: the axle element. Conveniently the means connecting the or each locating element to the connecting shaft comprises a tapered locking element, such as elements made by the German company Ringfeder or others. In a preferred construction each locating ring is provided with its own tapered locking ring (comprising two relatively moveable parts) which engages between the shaft and the locating ring. The action of tightening the locking element generates an axial movement of the locating ring relative to the shaft and thereby causes the radial body members and hence the impeller elements to be drawn inwardly by virtue of the co-operating tapered abutment surfaces. The provision of radial leading and trailing abutments on the radial body members gives rise to a circumferential wedging action as the radial body members are drawn inwardly by the annular locating rings.

The respective means to locate each annular locating element may be provided in addition to or as an alternative to the aforesaid axial clamping means. Other means of securing the annular locating rings to the axle may be used.

According to a preferred embodiment, the invention provides a turbine rotor having an axis of rotation and comprising a hub or axle element, a plurality of individual radial body members carrying one or more impeller elements, and two annular collars each having a frusto conical abutment surface, and wherein each radial body member comprises a frusto conical tapered flange to opposite ends thereof, the frusto conical tapered flanges to one axial end being co-operable with the frusto conical abutment surface of one annular collar, and the frusto conical tapered flanges to the other axial end being co-operable with the frusto conical abutment surface of the other annular collar, and further comprising means to secure the radial body members with regard to said hub or axle, and means acting via said frusto conical surfaces to draw the radial body members radially inwards.

In a preferred application the turbine rotor is a Pelton wheel runner and the impeller elements are buckets. The invention is described by way of example only hereinafter in relation to its application to a Pelton wheel runner. The use of conical tapered shoulders clamps the buckets by forcing them together, in a simple manner and has the advantage that it uses a minimum number of components and no precision fitting is required.

The present invention will now be described further, by way of example only, with reference to the accompanying drawings; in which:-

Figure 1 is a broken away front view of a Pelton wheel runner embodying the invention,

Figure 2 is a top view of the Pelton wheel runner of Figure 1,

Figure 3 is a partial section of Figure 1, and

Figure 4 is a perspective view of a bucket used in the embodiment of Figures 1 to 3.

Referring to the drawings, a turbine rotor of the type comprising a Pelton wheel runner is described and illustrated. However, whilst the present invention is described by way of example in relation to its application to Pelton wheel runner, it will be apparent to one skilled in the art that it can be applied to other types of turbine rotor, and the protection is not limited to a Pelton wheel runner.

The Pelton wheel runner according to the illustrated embodiment is made of a plurality of individual segments and each segment is formed with one bucket 1 in the described example and are conveniently referred to as bucket segments. The bucket segments are assembled together in a radial disposition relative to an axis of rotation X-X. Eighteen segments each with one bucket are shown in the illustrated example but it will be understood that the number of segments and the number of buckets per segment may vary according to any particular design requirement. In the illustrated embodiment the wheel is adapted to be mounted on a shaft 6.

Each bucket segment has a body 11 which has, in relation to the direction of rotation of the wheel, leading 13 and trailing 15 radial abutment surfaces. In assembling the plurality of bucket segments together to form a runner, the trailing abutment surface of the body of one bucket segment engages with the leading abutment surface of the body of the next adjacent bucket segment. For simplicity the radial abutment surfaces are plain surfaces, but could include ribs and rebates as

desired to limit machining and/or for location purposes. Any ribs or rebates should not inhibit radial movement for locating purposes as described further hereinafter.

The axial end faces of the runner are defined by opposite axial faces 17,19 of the individual bucket segments. The opposite axial faces each include an axially projecting radially tapered abutment 21 which, when the plurality of bucket segments are assembled together define an axially extending radially tapered annular flange 23 or frusto conical shoulder to each axial end of the runner. Each bucket segment body has a radially inwardly directed surface 25.

In the illustrated embodiment the hub of the Pelton wheel runner is defined by two annular elements 26,27 which form part of the impeller element locating means. Each annular element or locating ring has an annular recess 29 to capture the annular flange of the bucket segments. More particularly one annular element 26 has abutment means 31 disposed to engage with the radially tapered abutment 21 of each of the plurality of bucket segments disposed to one axial end thereof, whilst the other annular element 27 has abutment means 33 disposed to engage with the radially tapered abutment 21 of the opposite end of the bucket segment. More particularly each annular element 26,27 has a tapered frusto conical abutment. Preferably the angle of inclination of the respective tapered abutments of the bucket segments and the flange correspond.

First means for securing the two halves of the hub together is provided by a plurality of threaded bolts 35 whose heads 37 are engaged in respective recesses 38 in one of the halves and whose threaded shanks 39 engage with respective threaded holes 41 in the other half. As will be seen from Figure 3 the two annular elements are drawn together in an axial direction by the action of the bolt, thereby drawing the

tapered abutments thereof in to contact with the tapered flanges of the bucket segments. This in turn applies a radially directed clamping force to the bucket segments drawing them radially inwardly. The inward movement is resisted by the co-operating engagement between the radial abutment surfaces of the bucket segments. More preferably, and as detailed in the illustrated embodiment, each of the annular elements has its own tapered clamping element 34,38 by which each is secured individually to the shaft 6. The construction of the tapered locking elements is such that on tightening there is a relative axial movement between the shaft and the annular element. More particularly the tapered clamping element engages positively with the shaft whilst the annular element moves axially with respect thereto. This determines the final clamping force applied to the bucket segments and, where provided in addition to the first clamping means, overrides the action of the first clamping means.

In the illustrated embodiment the clamping bolts 35 are shown on substantially the same diameter as the locking element 38 and inset behind it. In an alternative design the clamping bolts are disposed at a greater radial distance from the axis X-X, closer towards the neck of the buckets, (especially for larger diameter units) and are accessible from one axial end when the element 38 or any alternative fixing element is in position.

By providing tapered flanges to either axial end of the runner relative to its central plane Y-Y and corresponding tapered flanges on both annular elements, the clamping operation will serve to draw the bucket segments uniformly radially inwardly which is desirable for most applications. However in some applications this may be seen as unnecessary and one of the axial ends of the runner may be provided

with a simple abutment surface on each bucket segment that is configured to allow radially inward movement under the action of co-operating tapered abutments of the other axial end of the runner.

CLAIMS

1. A turbine rotor having an axis of rotation and comprising a hub or axle element, and a plurality of individual radial body members carrying one or more impeller elements, and wherein the plurality of radial body members are secured with respect to said hub or axle element, each radial body member having leading and trailing radial abutment surfaces relative to the direction of rotation of the rotor that contact with the respective radial abutment surfaces of adjacent radial body members, and each radial body member further comprising at least one further abutment means, and the turbine rotor further comprising locating means in direct or indirect engagement with the further abutment means of the radial body members, and wedging means which is tapered in the radial direction relative to the axis of rotation and which acts between said abutment means and said locating means, and further comprising means acting via said wedging means to draw the radial body members radially inwards and hold them together as a unit.

2. A turbine rotor as claimed in claim 1 to which the radial body member is common to a plurality of radially disposed impeller elements.

3. A turbine rotor as claimed in claim 2 in which the plurality of impeller elements are formed integrally with the associated radial body member

4. A turbine rotor as claimed in claim 2 in which the plurality of impeller elements are discrete members that are secured to the body member by positive fixing means.

5. A turbine rotor as claimed in claim 1 in which each impeller element is formed with its own radial body member.

6. A turbine rotor as claimed in any one of claims 1 to 5 in which the body members form segments of the rotor and the leading and trailing radial abutment surfaces thereof are tapered so that they converge on and intersect at the axis of rotation.

7. A turbine rotor as claimed in any one of claims 1 to 6 in which the further abutment means comprises axial abutments means.

8. A turbine rotor as claimed in any one of claims 1 to 7 in which each radial body member comprises two of said further abutment means which are disposed to opposite axial ends thereof.

9. A turbine rotor as claimed in claim 8 in which the locating means comprises two locating elements that are engageable with a respective one of the two further abutment means of the radial body members.

10. A turbine rotor as claimed in any one of claims 1 to 9 in which the wedging means may comprise one or more separate members interposed between the further abutment means and the locating means.

11. A turbine rotor as claimed in any one of claims 1 to 9 in which the wedging means is incorporated in at least one of the further abutment means of each of the radial body members or said locating means.

12. A turbine rotor as claimed in any one of claims 1 to 11 in which the or each locating means comprises an annular locating ring which is provided with a frusto conical abutment.

13. A turbine rotor as claimed in any one of claims 1 to 9 or claim 12 when appended in any one of claim 1 to 9 in which the or each further abutment means of each radial body means is radially tapered.

14. A turbine rotor as claimed in claim 13 when dependent on claim 12 in which the radially tapered abutment means is in the form of a flange extending in the axial direction, and, wherein on assembly, the flanges of all the radial body elements form an annular frusto conical tapered flange that is acted on by the frusto conical abutment of the annular locating ring.

15. A turbine rotor as claimed in claim 9 in which means is provided for directly securing together the two locating elements.

16. A turbine rotor as claimed in claim 15 in which the securing means comprises an axial clamping means.

17. A turbine rotor as claimed in any one of the preceding claims in which means is provided to secure the locating means individually to a separate connecting member.

18. A turbine rotor as claimed in claim 17 in which the separate connecting member comprises the axle element.

19. A turbine rotor as claimed in claims 17 or 18 when dependent on claim 12 or any of claims 13 to 16 when dependent on claim 12 in which a respective means is provided to connect the respective locating rings to the connecting member.

20. A turbine rotor as claimed in claim 19 in which said means comprises a tapered locking element.

21. A turbine rotor as claimed in claim 20 in which each locating ring is provided with its own tapered locking ring comprising two relatively moveable parts which

engage between the connecting member and the locating ring and in which at least one locking ring acts to generate an axial movement of the locating ring relative to the connecting member and thereby cause the radial body members and hence the impeller elements to be drawn inwardly by virtue of the co-operating tapered abutment surfaces.

22. A turbine rotor as claimed in any one of claims 17 to 21 when dependent on claim 16 in which the respective means to locate each annular locating element are provided in addition to the aforesaid axial clamping means.

23. A turbine rotor as claimed in any one of the preceding claims in which the turbine rotor is a Pelton wheel runner and the impeller elements are buckets.

24. A turbine rotor constructed and arranged substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

ABSTRACT

A turbine rotor (eg: a Pelton wheel) is described which comprises a plurality of individual radial body members (11) comprising one or more impeller elements (eg: buckets) (1). The radial body members comprises segments which have leading (13) and trailing (15) radial abutment surfaces that contact with the respective radial abutment surfaces of adjacent radial body members when assembled as a unit. Each radial body member comprises at least one further abutment (21), preferably two at opposite axial ends (17,19) thereof, and locating means (26,27) is provided which co-operates with the further abutment means, preferably directly. Wedging means which is tapered in the radial direction relative to the axis of rotation of the turbine rotor, acts between the radial body members and the locating means, and means is provided which acts via said wedging means to draw the radial body members radially inwards to hold them together as a unit.

More particularly the locating means comprises two collars (26,27) which are engageable with a respective one of the axial end abutments (21) of the radial body members, and the wedging means comprises frusto conical formations of the further abutments of the radial body members and the locating means.

The means acting via the wedging means to draw the body members radially inwards comprises axial clamping means (35) operable between the two collars and/or taper action locating means (34,38) securing the two collars to a connecting shaft or axle element (6).

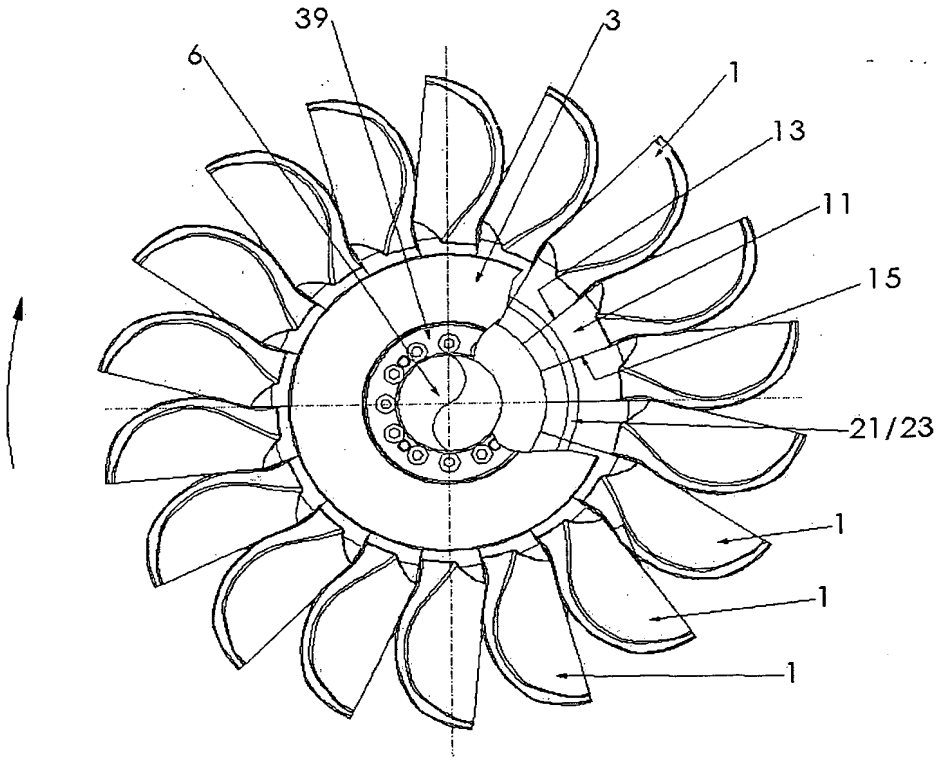

FIGURE 1

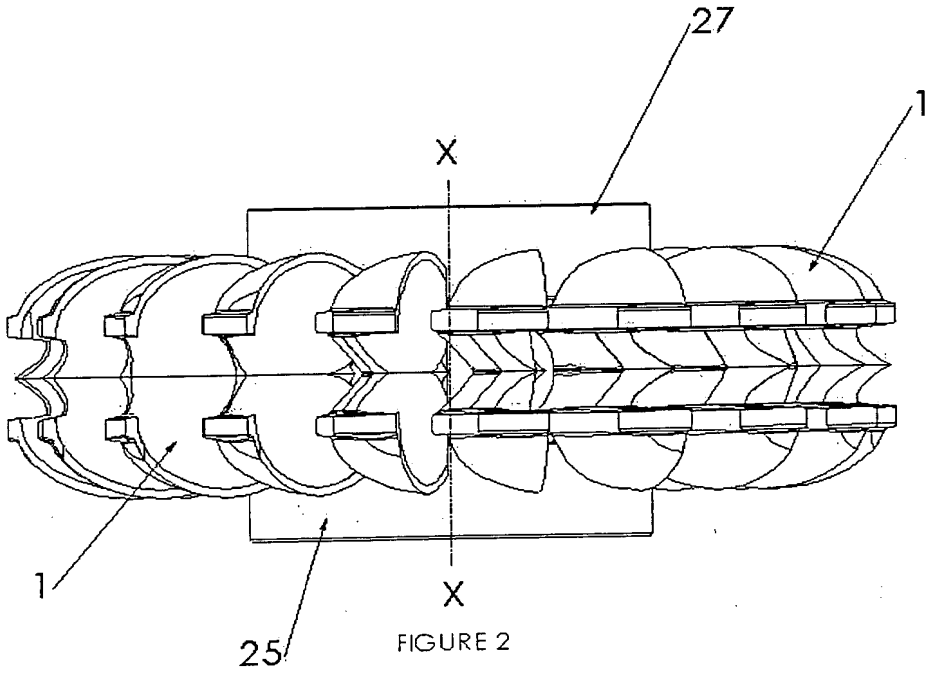

FIGURE 2

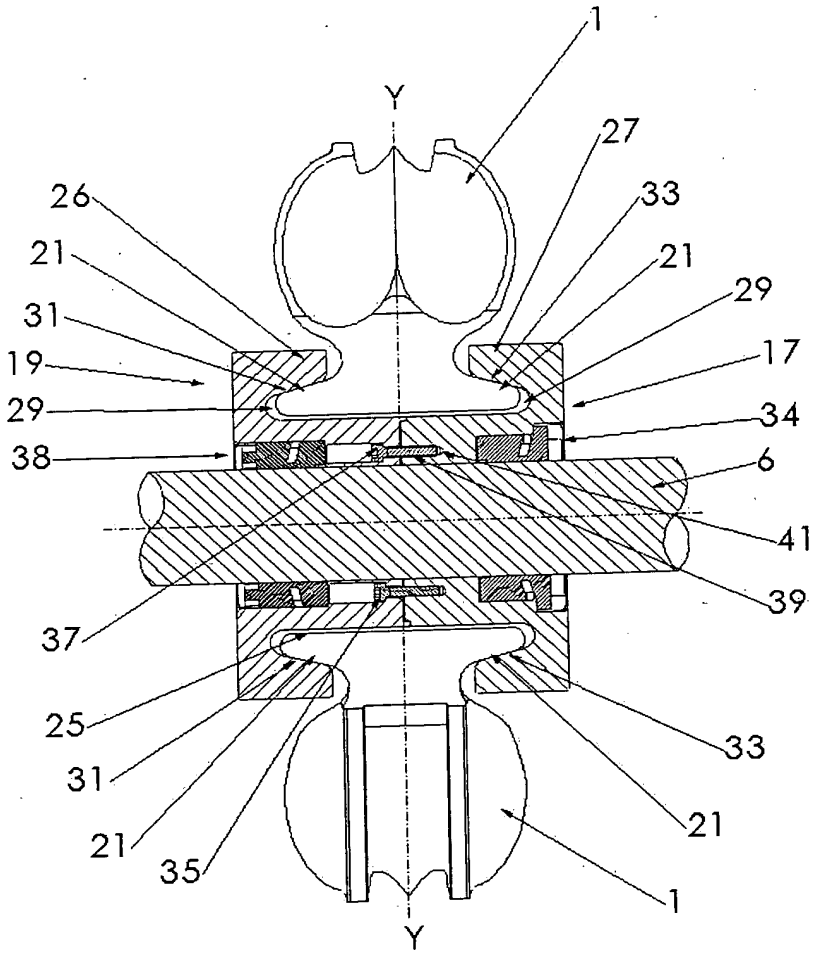

FIGURE 3

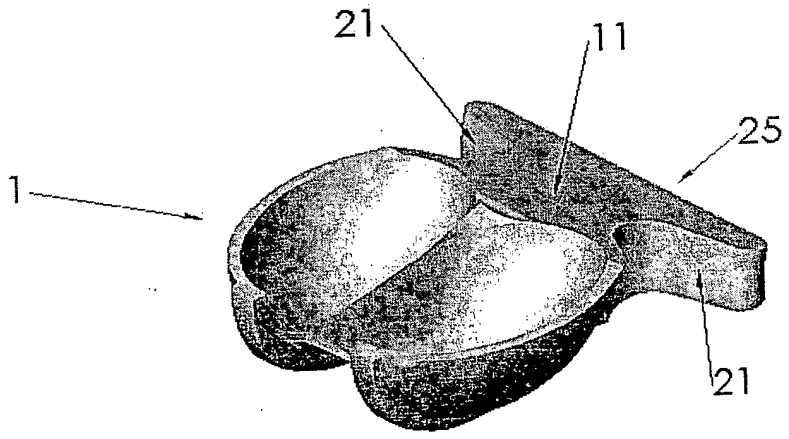

FIGURE 4

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